Autumn territoriality of Chinese Grouse *Bonasa sewerzowi* at Lianhuashan Natural Reserve, Gansu, China

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Abstract During 1995 to 2007, 70 Chinese grouse (31 males and 39 females) were followed using radio telemetry at Lianhuashan Natural Reserve, Gansu Province, China. The typical habitat of Chinese grouse consisted of spruce-fir forests intermixed with thickets of many willow species (2600 m to 3500 m a.s.l.). The territorial behaviour of Chinese grouse culminated in October, as measured by whole-day registration of noisy drumming flights (dominant behaviour), flutter jumps (less frequent than in spring), and encounters of neighbouring males. Agonistic behaviour of males includes chasing each other or running in parallel, uttering two types of aggressive song, and standing in front of each other on the ground or in trees. Fighting was observed only in spring, but might occur in autumn too. Peaks of the diurnal territorial activities were found at 0600 - 0800 and at 1500 - 1800. The ecological consequences of autumn territoriality in comparison with hazel grouse are discussed.

Keywords *Bonasa sewerzowi,* Chinese grouse, Lianhuashan reserve, territorial behaviour.

Introduction

The poorly known Chinese grouse *Bonasa sewerzowi* inhabits the coniferous forests in the high mountains of Gansu, Qinghai, Sichuan, Yunnan and Eastern Tibet Provinces, China. Whereas the territorial and mating behaviour of the Chinese grouse in spring has been described earlier (Klaus et al*.,* 1996; Sun & Fang, 1997; Scherzinger et al*.,* 2003), their behaviour regarding the establishment and defence of territories in autumn has not yet been reported. From our radio telemetry studies, we have learned that both males and females establish territories in autumn and that both sexes form flocks in winter. Consequently, territorial activity is interrupted while they are in flocks. Studying a subpopulation of Chinese grouse, partially colour-ringed and wearing radio transmitters, we addressed the following questions: 1) which behavioural components are involved in territorial activities?; 2) are there differences in territorial behaviour in autumn and spring and in its diurnal distribution?; 3) is the pattern of foraging activity different in autumn and spring?

Study area and methods

Study area

The study was conducted in the Lianhuashan Natural Reserve in Gansu Province, central China (34°56’ - 58’N, 103°44’-48’ E). The highest peak is 3,578 m a.s.l. About 30% of the reserve (12,550 ha in total) is forested, but only 1,170 ha is mature coniferous forests growing on limestone-derived soils, mainly on northern slopes (Klaus et al*.,* 2001). The tree canopy is dominated by *Abies fargesii, Picera asperata, P. purpurea, P. wilsonii,* three species of *Betula* and many species of *Salix.* The optimal habitats of Chinese grouse are characterised by the close vicinity of coniferous forests with a shrub layer of different species (*Sinarundinaria nitida, Berberis, Lonicera, Rhododendron, Rosa, Viburnum, Crategus, Spirea, Cotoneaster, Rubus* etc.) that provides cover and groups of deciduous trees and shrubs (*Salix* spp., *Betula* spp., *Sorbus* spp., *Hippophaae rhamnoides*) that provide food in winter. The study area is described more thoroughly in Klaus et al*.,* (1996; 2001) and Sun et al*.,* (2003; 2006).

Methods

Foraging and territorial activity of 18 colour-ringed and radio-tagged individuals was observed during 10 field days in May 9 - 18, 1997 (with additional observations in May 2007 for control, data not included in this work) and 10 field days in October 13 - 22, 2000 (n = 12 colour-ringed and radio-tagged males and females, with additional observations in October 2006 for control, not included in this work). Entire-day observations concentrated on

foraging males and females and the territorial activities of males (flutter jumps, noisy drumming flights, encounters). All types of behaviour (noisy drumming flights, flutter jumps and encounters of neighbouring males) seen or heard of a given number of birds observed per hour of the day were summed. In the case of foraging, the number of birds seen per hour along our fixed transect line (males and females combined) was summed. The relative values of all performances per hour of the day were obtained by setting the sum of these territorial behaviours observed during the 10-day period to 100%. The 10-day sum of any territorial performance was divided by the 10-day-sum of all performances and the resulting quotients were drawn as a function of day time. Times given are local times in China. In the description of the grouse behaviour, we follow the terminology of Hjorth (1965).

The weather during both 10-day periods was comparable, varying between warm, sunny days and rain or even snow fall. The sum of the 10-day periods included the whole range both in May and October. The day length was different –about 11 hours in October 2000 (as an example: October 13: sunrise 7.12; sunset 18.34). The day length in May 1997 was 14 hours (as an example: May 9: sunrise 6.08, sunset 20.00). This resulted in different length of grouse activity periods, but not in the shape of activity curves and in the relative proportions of the performances regarded here.

Results

The main element of territorial activity is the bi-phasic flutter jump, composed of a rising phase, a gliding and a landing phase (sonogram see Scherzinger et al., 2006). The noisy drumming flight was recorded when the birds left or visited the roosting trees or when changing trees during feeding. Series of wing-beats were interrupted by gliding, producing acoustic signals.

When neighbour males approached each other, conflicts followed. These were accompanied by two types of vocalizations, the aggressive song (sonogram see Klaus et al., 1996) and the trill song. Encounters were observed on the ground (more frequent) or in feeding trees or shrubs. During the encounter, the males started singing, often in duet, and climbed within the shrubs at distances of 1 - 5 m from each other. Chasing flights might follow. After a male visited a neighbour's territory, both rivals ran on the ground, one chasing the other or in parallel. When they interrupted the chase, they started to feed or crouch on the ground. During the entire encounter they uttered the aggressive or the trill songs (Klaus et al., 1998). The conflict culminated when males approached each other and stood in an erect pose in front of each other. Synchronous head-bowing dominated this behaviour. Actual fights occurred rarely. They consisted of jumping into the air, pecking and loud wing-beating. Serious fights were observed only in spring, but they may occur in autumn too.

In the early morning in autumn, after leaving the roost trees, the Chinese grouse fed in willows. In spring, flutter jumping started before foraging. In both autumn and spring, foraging prevails in the afternoon (67%) with peaks between 1630 and 1830 (or 1930 in spring due to the prolonged daylight in May) (FIG. 1). The morning feeding period (0400 - 1200) was more extended in spring (6.30 - 12.30). In autumn, there was a more pronounced peak between 0630 and 0830. In both spring and autumn, 33% of feeding grouse were recorded in the morning (spring: n = 46, autumn: n = 59). Altogether, 143 foraging grouse were observed in spring and 177 in autumn.

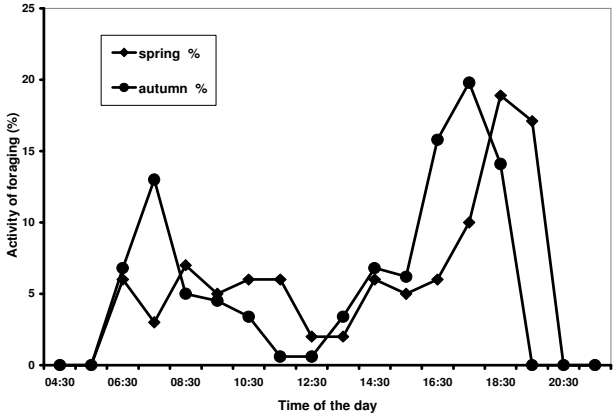

FIG. 1 Daily distribution of the relative frequency (%) of foraging Chinese grouse (males and females combined) in autumn and spring at Lianhuashan Natural Reserve, Gansu Province, China.

The diurnal distribution pattern of territorial behaviours by males in autumn (% per hour of the day) is summarized in FIG. 2. In the morning, activities consisted of flutter jumps (14%, n = 28), noisy flights (3.5%, n = 6), and encounters (6%, n = 13). Before noon, only 23.5% (n = 47) of all territorial performances were recorded, with peaks around 0830 and a resting time between 1030 and 1330. In the

afternoon, the territorial activity was more pronounced: noisy flights dominated (41%, n = 81), followed by flutter jumps (20%, n = 39), and encounters (15%, n = 32). Overall, the dominating territorial activities were territorial flights (45%), flutter jumps (34%), and encounters (21%). Peaks of activity were recorded between 1530 and 1730, before intensive foraging took place (FIG. 1). In total, 200 territorial performances were registered in the 10-day period.

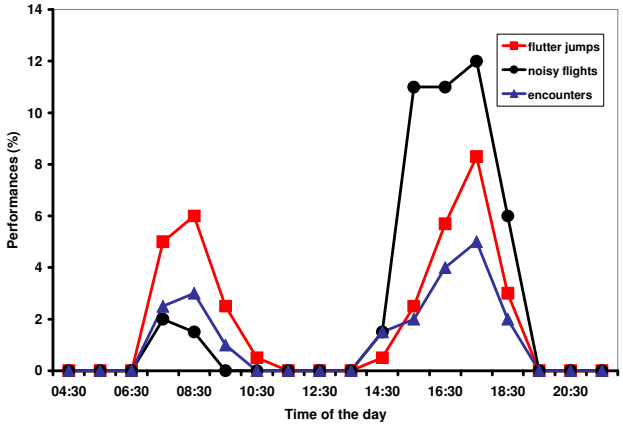

FIG. 2 Frequency distribution (%) over the day of three different forms (flutter jumps, noisy flights, encounters) of territorial behaviour exhibited by Chinese grouse males in October 2000 registered during a 10-day period of pronounced activity at Lianhuashan Natural Reserve, Gansu Province, China.

The diurnal distribution of territorial behaviour in spring differed from that in autumn. In spring, flutter jumps dominated, with the highest peak in the morning between 0530 and 0730 (73%, n = 467) and a smaller one in the afternoon (13%, n = 84) (FIG. 3). Noisy flights were much less frequent: 6% in the morning (n = 37) and 3% in the afternoon (n = 21). Encounters were registered in the morning (2.8%, n = 18) and in the afternoon (1%, n = 7). Overall, 82% (n = 522) of all territorial performances (n = 634 in the 10-day period) were recorded before noon and 18% (n = 112) in the afternoon.

A global test showed a significant difference in the frequencies of flutter jumps, noisy flights and encounters between spring and autumn (χ_2^2 = 232.2, P < 0.0001). Flutter jumps were the dominating territorial performance in spring (87% of all performances versus 34% in autumn [χ_1^2 = 228.7, P < 0.0001]). In autumn noisy flights were dominant (45% vs. 9.3% in spring, χ_1^2 = 125.6, P <0.0001), followed by encounters (21% vs. 4% in spring [χ_2^2 = 70.2, P < 0.0001]). The mean length of the time interval between two successive flutter jumps of individual males also differed between spring and autumn, 2.5 ± 2.0 min (n = 75) and 21 ± 24 min (n = 40), respectively, (t = 5.23, d.f. = 42.2 P < 0.0001).

Foraging activity of Chinese grouse (both sexes combined) was concentrated during the second half of the day (67% of all observations of foraging grouse), with only small differences between spring and autumn. Comparing the peaks of the different activities in the morning, it was evident that males start their flutter jump display in spring before feeding. In contrast, foraging in autumn culminates before territorial activities started.

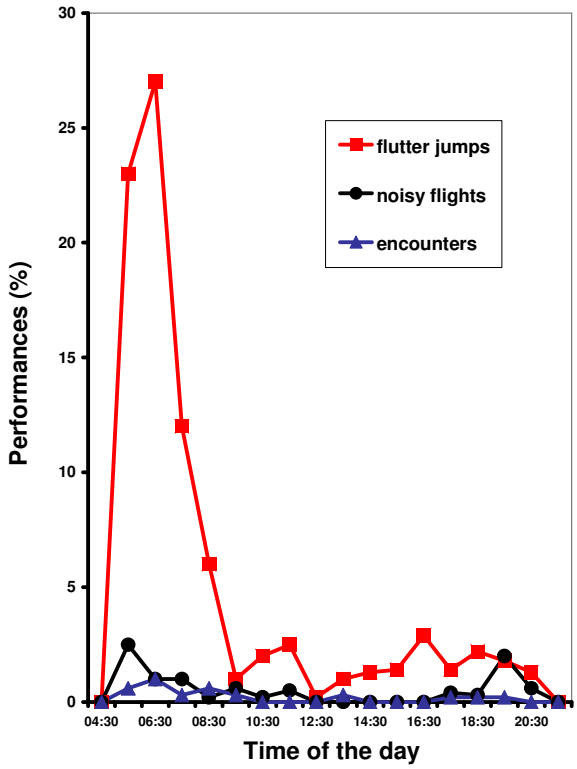

FIG. 3 Frequency distribution (%) over the day of three different forms (flutter jumps, noisy flights, aggressive encounters) of territorial behaviour exhibited by Chinese grouse males in May 1997 registered during a 10-day period of pronounced activity at Lianhuashan Natural Reserve, Gansu Province, China.

Discussion

In hazel grouse, both males and females defend year-round territories throughout most of their range, with peaks of activity in spring and autumn (Swenson, 1993; Bergmann et al., 1996). Territorial activity (whistling, flutter-jumping, and rarely encounters) increases markedly just after the breaking-up of broods in early September - October, when yearlings start to find their own territories. At this time the birds respond to imitations of the territorial song with a hunter's whistle (Wiesner, 1977). In both autumn and spring, hazel grouse show peaks in response to the play-back (of the whistling song), but only in spring do they show a peak in spontaneous advertisement. Border disputes (encounters) were more common in autumn. In addition, responding hazel grouse males sing more often in spring than in autumn, when wing-produced sounds were more common (Swenson, 1991). In contrast, in both autumn and spring male Chinese grouse perform all three types of performances spontaneously. The activity pattern of Chinese grouse both in spring and in autumn was biphasic, with peaks in the morning between 0630 and 1000 and in the afternoon between 1500 and 1800 (autumn), and peaks in the morning between 0430 and 0830 and in the afternoon between 1500 and 2000 (spring, FIGS. 1 - 3).

Why do the males establish territories before the break-up of the territory system?

The occupancy of a territory in autumn with a good supply of deciduous trees (winter food) and conifer cover is assumed to be crucial for the survival of both the hazel grouse and the Chinese grouse. In late October when frost and snow in Lianhuashan became common, the grouse entered flocks and went to the preferred winter habitats, first the females (mean 3.63 ± 0.77 km, n = 4) and then most of the males (mean 1.42 ± 0.44 km, n = 5). This resulted in a breakdown of the territorial system although some older males stayed in their territories in winter (Sun, 1997).

In the northern and eastern parts of their range, hazel grouse also tend to form flocks composed of both sexes in late autumn and winter, which Swenson et al. (1995) interpreted to be an anti-predator behaviour that enables the bird to use additional food resources in more open habitats. As a consequence of flock formation, the territorial system established in autumn breaks down and is re-established in early spring. Autumn territoriality should benefit the territory owners, who should have the advantage of previous ownership when they return to their territories after the dissolution of flocks in spring.

Most of the Chinese grouse in a local population join the flocks in a harsh winter with deep snow (unpublished results). The flocks over-wintered at places where food resources (buds and twigs of willows and berries of sea buckthorn) are most abundant. We suggest that flock formation in Chinese grouse, as in the hazel grouse, has evolved as a response to predation pressure in the open habitats, where the birds find a rich supply of food resources. Radio telemetry data showed that, after the resolution of flocks in late March to early April, first the males and later the females returned to their territories. We suggest that Chinese grouse select territories to provide rich food and cover for the early part of the reproduction period (pre-laying, laying and incubation). Swenson (1991) found that the hazel grouse, one of the smallest grouse, depends strongly on rich food in the pre-laying period, resulting in territoriality also in females. The Chinese grouse, which is the smallest of all the grouse (Sun et al., 2004), lives in harsh high mountain habitats. We suggest that establishing a well defined territorial system in the autumn benefits the reproduction of territory holders in the following spring.

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Biographical sketches

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